Cultivation of Neglected Tropical Fruits With Promise

Part 5. The Canistel and Its Relatives

U.S. Department of Agriculture
Science and Education Administration
August 1978

This publication is available from the Mayagüez Institute of Tropical Agriculture, Science and Education Administration, P.O. Box 70, Mayagüez, P.R. 00708.

Other publications in this series:

Part 1. The Mangosteen. ARS–S–155.
Part 2. The Mamey Sapote. ARS–S–156.
Part 3. The Pummelo. ARS–S–157.
Part 4. The Lanson. ARS–S–171.

This series was formerly published by the Southern Region of Agricultural Research Service (ARS). On January 24, 1978, ARS and three other USDA agencies—Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—were merged to form a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture. This series continues under the SEA imprint.

Cultivation of Neglected Tropical Fruits With Promise. Part 5. The Canistel and Its Relatives, August 1978

Published by the Office of the Regional Administrator for Federal Research (Southern Region), Science and Education Administration, U.S. Department of Agriculture, New Orleans, La. 70153

CONTENTS

ILLUSTRATIONS

TABLES

Cultivation of Neglected Tropical Fruits With Promise

Part 5. The Canistel and Its Relatives

By Franklin W. Martin and Simon E. Malo[1]

ABSTRACT

The canistel, *Pouteria campechiana* (HBK) Baehni, and its close relatives, the lucmo, *P. obovata* HBK, and the abiu, *P. caimito* (Ruiz & Pav.) Radlk., are excellent fruits of the American Tropics which are not well distributed and are little known. All are about the size of an apple or an orange, and they are produced on attractive, chiefly evergreen trees. These species do well in areas with cool nights and have adapted somewhat to dry regions; the canistel seems to be the most adaptable. All can be propagated from seeds, but named varieties of lucmo are propagated by grafting. Cultural requirements are described based on the fragmentary information available. The canistel and the lucmo have a strong aroma and a mealy pulp, yellow or orange. Although the fruits are often eaten by hand, the pulp, either fresh or dry, can be used in the flavoring of drinks and desserts. The fruits are good sources of provitamin A. The fruit of the abiu is gelatinlike in consistency and must be eaten when fully ripe to avoid a sticky pulp. These three fruits merit attention and would probably be readily accepted by most people. Export markets also seem feasible. KEYWORDS: abiu (*Pouteria caimito*), canistel (*Pouteria campechiana*), eggfruit, fruits, lucmo (*Pouteria obovata*), lucuma, plant cultivation, tropical agriculture (fruits).

INTRODUCTION

Among the lesser known fruits of the American Tropics which deserve to be better known are three members of the genus *Pouteria:* the canistel, *P. campechiana* (HBK) Baehni (fig. 1), and two of its close relatives, the lucmo, *P. obovata* HBK, and the abiu, *P. caimito* (Ruiz & Pav.) Radlk. Although they can grow from Florida and Mexico to Chile and Uruguay, and from temperatelike highlands to humid, tropical lowlands, these fruits are only known and enjoyed in few localities and are seldom utilized commercially. Their botany in natural habitats has not been studied thoroughly. In fact, the botanical literature is confusing and contradictory even with respect to the principal species of each genus and the relationship of the genera to the family.

Nevertheless, these three *Pouteria* species were well known by the great pre-Columbian civilizations of South and Middle America, as shown by images of the fruit on woven cloth and clay vessels. Men were probably responsible for distribution of these species. Their present wide distribution makes it difficult to trace a specific origin.

[1] Horticulturist, Mayagüez Institute of Tropical Agriculture, Science and Education Administration, U.S. Department of Agriculture, P.O. Box 70, Mayagüez, P.R. 00708; and horticulturist, Agricultural Research and Education Center, University of Florida, 18905 SW. 280th St., Homestead, Fla. 33030.

FIGURE 1.—Canistel fruits (ripe), seeds, and leaves.

The canistel and its relatives merit widespread testing and use throughout the Tropics. They are unique fruits in many respects and should delight people everywhere because of their attractive appearance, aroma, and taste. They can be consumed either fresh or processed into many home or commercial products.

THE CANISTEL AND ITS RELATIVES

Taxonomy and Nomenclature

The canistel and its relatives belong to the Sapotaceae, a family of trees and shrubs found throughout the Tropics and in some subtropics. It is known as the guttapercha family because of the gum that is taken mostly from the taban (Malay guttapercha natotree), *Palaquium gutta* Baill., of Southeast Asia (*2*).[2] The family also includes American trees that bear valuable fruits, such as the mamey sapote, *Calocarpum sapota* (Jacq.) Merr.; the caimito (starapple), *Chrysophyllum cainito* L.; and the sapodilla, *Achras zapota* L., well known for its latex, chicle, at one time the main ingredient in chewing gum.

The family Sapotaceae has traditionally been difficult to classify. Recent publications (*4*, *5*, *8*) list a variety of botanical binomials for the same members of this family. Vernacular names have acquired considerable importance, because they are the only means by which horticulturists understand which species people are talking about. Classification of the types that bear edible fruit has been at times arbitrary and erroneous because judgments were based on poor herbarium specimens, and occasionally because good biosystematic evidence of speciation was lacking.

The canistel, the lucmo, and the abiu come from widely separated habitats and are not as well known as the mamey sapote, the caimito, and the sapodilla, but they deserve further taxonomical attention and recognition by growers and horticulturists. Table 1 lists the botanical

[2] Italic numbers in parentheses refer to items in "References" at the end of this publication.

Table 1.—Botanical synonyms and common names of the canistel, the lucmo, and the abiu

Scientific name	Botanical synonyms	Common names	Country or region
Pouteria campechiana		Canistel	West Indies; Philippines.
	Lucuma campechiana HBK	do	Cuba; Florida; U.S.A.
	L. laeteviridis Pitt.	Mamey ciruela	Mexico.
	L. nervosa A. DC.	Zapotillo	Costa Rica.
	L. palmeri Fern.	Zapote amarillo	Do.
	L. salicifolia HBK	Kaniste	Yucatán.
	L. sphaerocarpa A. DC.	Zapote borracho	Yucatán peninsula; Mexico.
	Pouteria campechiana var. *nervosa* Baehni.	Mamey de Campeche.	Latin America.
	P. campechiana var. *salicifolia* Baehni.	Huicumo	Mexico.
	P. nervosa	Huevo vegetal	Puerto Rico.
	Richardella nervosa Pierre	Ties	Cuba; Florida.
	R. salicifolia Pierre	Eggfruit	Florida; U.S.A.
Pouteria obovata		Lucmo (lugmo)	Ecuador.
	Achras lucuma Ruiz & Pavon	Lucmo	Peru.
	Guapeba nitida Pierre	Colorado	Do.
	Lucuma bifera Mol.		
	L. nitida A. DC.		
	L. obovata HBK		
	Pouteria lucuma Kuntze		
	P. nitida Radlk.	Lucuma	Peru; Chile.
Pouteria caimito		Abiu	Brazil.
	Achras caimito Banth	Cauje	Ecuador.
	Guapeda caimito Pierre	Caimo	Colombia.
	Labatia caimito Mart.	Abieiro	Brazil.
	Lucuma caimito Roem & Sch.	Abio	Do.

synonyms and common names used in different countries.

Origin and Habitats

The canistel, *P. campechiana* (HBK) Baehni, is probably the best known of the three species. Widely adaptable, it has been introduced with considerable success to many warm regions of the world, including the Philippines (*1*, *4*) and Malaya (*2*). It probably originated in Mexico and Middle America, where it has been known since pre-Columbian times, as shown by the Mayan names Kaniste, Huicomo, and others (*10*, *13*). The canistel is widespread in Cuba and the Caribbean, where it is much appreciated and used. It grows in Florida and the Florida Keys on difficult sites, withstanding frost and shallow, calcareous soils, which lose much of their moisture during the dry season of March through May.

The lucmo, *P. obovata* HBK, is another valuable species from southern Ecuador, Peru, and northern Chile. The normal habitats of this species are high, rather dry, inter-Andean valleys between 1,500 and 2,500 m, where the temperature may be warm a few hours around noon but cool the rest of the day and seldom freezing. The lucmo has been taken to Costa Rica, but the trees are not adapted to the constantly humid, warm weather, and the quality of the fruit is inferior. Nevertheless, species that grow well in the coastal lowlands of Peru have been mentioned. The lucmo shows a wide adaptation to soil conditions but prefers deep, alluvial soils.

Many people think that the abiu, *P. caimito* (Ruiz & Pav.) Radlk., is the best of this group. In contrast to both the mealy, yellow flesh of the canistel and the firm, salmon flesh of the lucmo, the pulp of the abiu is whitish, translucent, and of a jellylike consistency, resembling in flavor and appearance the green caimito, *Chrysophyllum cainito* L. The abiu is native to the areas of the headwaters of the Amazon and its tributaries, and it is well adapted to the warm, humid conditions that predominate in this region.

A number of wild and minor cultivated species of *Pouteria* also deserve more recognition because

they are edible and useful. A good example is *P. hypoglauca* (Standl.) Baehni, highly esteemed in El Salvador, where many valuable horticultural seedling forms are found. For the most part, botanical studies and classification of *Pouteria* and *Lucuma* species have been inadequate. Some of the edible species are given in table 2.

Botanical Description

The canistel and its relatives are tropical evergreens, which shed their leaves more or less continuously throughout the year. Lucmo trees, however, may remain almost bare for a few weeks during the dry season. The form of the trees varies from upright to rounded with a somewhat open structure. To bear fruit, young seedlings may take from 3 years (for the canistel) to 8 years or more (for the lucmo). Old lucmo trees may reach 20 m in height in deep alluvial soils, with a rounded, attractive crown. Isolated, large lucmo trees become more valuable for timber as they age, and are quickly felled. The abiu is the smallest of the three but can also attain heights of 15 m or more.

The foliage is similar in all the species (fig. 2). The leaves are simple, alternate, and most often concentrated at the end of small branches, as with most Sapotaceae. Leaf shape varies considerably even within a species. The color is dark green, and the surface usually smooth and shiny. The lucmo has stiff, leathery leaves, mostly obovate, rounded at the apex, and subacute at the base. In all species, the leaf size ranges from 12.5 to 25 cm.

The hermaphroditic flowers are small and inconspicuous in all species, but they are slightly larger in the lucmo. The corolla is tubular, four- or five-toothed, and pale green to whitish. The flowers occur abundantly among the leaves near the tips of the branches on growth of less than 2 years. Fruits are often pointed at the blossom end; most are typically ovoid, but some are spherical and compressed, and less often they are elongate (fig. 3). Diameter varies from 4 to 5 cm and length from 5 to 17 cm. A lucmo fruit can weigh 1.5 kg, the largest of the three species.

Canistel fruits are yellow to orange with a smooth to slightly rugose surface. The epidermis is easily ruptured when mature, showing a somewhat mealy pulp (fig. 4) similar in appearance and texture to a cooked egg yolk, but sufficiently moist in the mouth. Often, only one seed occurs in the best forms, but several seeds are not unusual. The seed is large, 3 to 5 cm long, triangular in cross section, and shiny, dark brown on two sides, with a large, light-colored, rough hilum on the ventral side. At maturity, the odor of the pulp has been described as musky. The smell is strong and penetrating in some varieties and not agreeable to all people. The taste is unique, rich, and sweet.

Figure 2.—Foliage of a lucmo seedling, typical of the canistel and its relatives.

Table 2.—Other *Pouteria* and *Lucuma* species

Scientific name [synonym(s)]	Common name(s)	Country or region
Pouteria hypoglauca (Standl.) Baehni [*Lucuma hypoglauca* Standley].	Pan de la vida, Choch, Socovite, Palo de calentura.	Central America; El Salvador.
P. macrocarpa (Huber) Baehni [*Lucuma macrocarpa* Huber; *Pouteria venosa* (Mart.) Baehni].	Cutite-grande	Amazon headwaters area.
P. macrophylla (Lam.) Eyma [*Lucuma rivicoa* Gaertn.].	Cutite	Do.
P. multiflora Eyma	Jacana	West Indies.
P. pariry (Ducke) Baehni [*Eglerodendron pariry* (Ducke) Aubr. & Pell.; *Lucuma pariry* Ducke].	Pariri	Amazon headwaters area.
P. speciosa (Ducke) Baehni [*Lucuma speciosa* Ducke].	Pajura de Obidos	Do.
P. ucuqui Poris & Schulte	Ucuqui	Brazil.
Lucuma burbinata		Chile.
L. dissepala Ducke	Abiurana grande	Brazil.
L. lasiocarpa Mart.	Abiurana	Do.
L. laurifolia A. DC.	Guapeba	Do.
L. paraensis Stand.	Abiu grande	
L. parviflora Berth.	Muira-pixi	Brazil.
L. procera Mart.	Macarandiba	Do.
L. sellowii A. DC.		Do.
L. serpentaria H.B. et K.		Cuba.
L. torta A. DC.	Grao-de-galo	Brazil.
L. valparadisea	Palo colorado	Chile.

FIGURE 3.—Ripe canistel fruits.

FIGURE 4.—Seeds and soft, mealy pulp of ripe canistel fruits. (Cutting has misshapened these fruits.)

The lucmo fruit is similar to the canistel. It is round to broadly oval, occasionally pointed at the apical end, and green to greenish yellow, with yellowing increasing at maturity. Some fruits are brownish or salmon and characteristically marked with russet. The skin is thin and easily broken. The pulp is light to deep orange and firm even in fully ripened fruit, with a sweet flavor typical of the Sapotaceae (considered excellent by some). A fruit usually has two seeds, rounder than those of the canistel but otherwise similar.

The abiu fruit is elliptic to round, 5 to 10 cm long, and bright yellow with a tough skin. Several large seeds are contained in a white to translucent, jellylike, pleasantly flavored pulp that must be eaten at peak maturity to avoid the sticky latex.

VARIETIES

Members of the genus *Pouteria* have been neglected from a horticultural point of view. Only a few canistel cultivars worth propagating exist in Florida and other places. Seedling trees vary considerably in size, shape, number of seeds, and overall quality.

In Peru and Chile, attempts have been recently made to establish named lucmo cultivars. Seedling varieties have been placed in two groups. One, called Seda (silk), is smooth, but the dark pulp is mealy, like a cooked egg yolk. The second group is much lighter in color, but the pulp is hard and not usually eaten fresh. Many fruits fall into intermediate categories. In Peru, three cultivars selected from many seedling trees have been designated Lucmo B–1, B–2, and B–3. They yield well and have small seeds and other favorable characteristics. Calzada (*3*) has carefully described these cultivars, and they are available as grafted trees in Peru. In Chile, cultivars have not been named, but grafting has stimulated flowering of young trees in as little as 15 months, according to Saavedra (*12*, *13*).

The abiu occurs both in wild and in cultivated forms in the Amazon area and is characterized by great variation in physiological and morphological characteristics. So far, however, no attempt has been made to select the better seedlings as cultivars and to establish them by asexual propagation.

Planting of commercial orchards would be more feasible if grafted varieties of canistel and its relatives were established. Grafting assures high fruit quality and uniformity, the principal requirements of the modern fruit industry. Availability and distribution of superior cultivars should stimulate the market for these potentially valuable fruits.

CULTIVATION

CLIMATIC REQUIREMENTS

The canistel and its relatives seem to have adapted strictly to frost-free climates. The Lucmo, probably the most versatile of these species, grows from as high as 2,500 m in equatorial regions to sea level in the higher latitudes. The lucmo is found as far south as latitude 33° S. in

Chile (7), well into the Temperate Zone. In these areas, the maximum temperatures are higher and minimum temperatures lower than those found in equatorial regions.

The canistel is well adapted to the subtropics. In southern Florida, its northern expansion is limited only in areas subject to severe frosts. It withstands light frosts of short duration in the Miami area. The abiu, on the other hand, seems to be strictly tropical in climatic requirements; the best environment is the uniformly warm and humid climate of the Amazon and its tributaries. It does not withstand frost and low relative humidity as well as the other two species. It grows and fruits in the Miami area of Florida but only under good care and in well-protected locations.

Adaptation to day lengths of tropical and subtropical areas seems to be ample in these species, for all of them flower and bear fruit anywhere in these regions. The canistel and the lucmo tolerate dry climates well and seem to be adapted to medium rainfall. All species need good drainage where rainfall is heavy and irrigation where rainfall is light. The abiu needs more water than the other two species.

In summary, the canistel and its relatives are widely adaptable. They are easy to grow, and plantings should be tried in all parts of the Tropics and the subtropics.

Soils

Wide distribution and ready growth suggest that these species are tolerant to a wide variety of soils. The canistel grows in southern Florida and in the Florida Keys in soils of low fertility: deep sands or shallow calcareous soils with minor element deficiencies that are a problem for other fruit trees. Iron deficiency is seldom a problem with the canistel in soils in the Homestead-Rockdale area of Florida, but the abiu seems to thrive only in the slightly alkaline, neutral, or slightly acid sands of the Miami area. This species seems to be somewhat more selective in its requirements in tropical situations. The lucmo grows satisfactorily in rocky ground, in soils ranging from loose sands to heavy clays, but it does best in well-drained loams high in organic matter. All of these species suffer from flooding; the lucmo and probably the canistel can tolerate moderate salinity.

Propagation

Seeds

The canistel and its relatives have been propagated chiefly from seed. Seeds characteristically lose their viability rapidly and should not be stored for more than a few days. Fresh seeds should be cleaned and dried slightly in the shade and kept in slightly moistened perlite or moss at 15° C, if possible. Some people scratch the seed coat with a file to facilitate the absorption of water, but under normal conditions this is not necessary if the seed is fresh. Seeds should be disinfected with a fungicide used for seed treatment.

The medium for seed germination should be well drained but without a tendency to dry out, and it should be well aerated. The medium can contain peat moss, composted organic material, vermiculite or perlite, and crushed charcoal as well as sand and soil. The medium should be fumigated or sterilized by steam heat before seeds are sown.

The seeds are planted in flats in furrows or rows a few centimeters apart, depending on the species and the size of the seeds. Soil sufficient to cover them is added, and they are watered, preferably with unchlorinated water. Highly chlorinated water may reduce germination. The flats should be kept in partial shade and watered as needed to prevent drying out of the seeds. Temperatures should be moderate (23°–26° C), and high humidity is initially desirable.

Careful attention pays off in uniform germination and healthy seedlings. Germination begins about 2 weeks after sowing and continues up to 5 weeks. Young seedlings of all of these species are vigorous. Initial growth is related to the size of the seed. The large seeds of the lucmo and the canistel produce fast-growing seedlings, and the seedlings from the small abiu seed grow at a slower rate. Germinating seedlings should be examined for fungus diseases.

When the seedlings are ready for transplanting, which depends on size and crowding, they are carefully transferred to plastic bags or other containers of a sterile soil mix. Roots of the small seedlings should never be allowed to dry out. For field planting, bags or containers holding approximately 8 l (2 gal) of soil are preferred, because they support plants large enough to do well without special care. It is difficult to trans-

plant the canistel and its relatives when they are small and when the soil has been removed from the roots. Therefore, it is suggested that trees remain in their containers until the day of transferring to the field.

Grafting

The recommended method of propagation is grafting, particularly if superior cultivars are available (*6*, *13*). Choice trees can be multiplied and fruit at an early age (fig. 5). The technique works most successfully with the canistel and the lucmo and is less effective with the abiu.

The most common grafting techniques for the canistel and the lucmo are the side-veneer graft and the bud patch (chip budding), although cleft grafting (the terminal-wedge graft) of young plants is also successful, particularly with the lucmo. Other types of grafts such as the splice or whip graft and even shield budding have been tried with less success.

Grafting is a technique requiring experience and careful attention. Trees should be grafted while in the holding containers, when 9 to 10 months old and about 1 cm in diameter. The knife blade should be extremely sharp. Polyethylene plastic strips for tying are generally preferred to rubber or other materials. The scion should come from relatively young wood but should not be too succulent. The side-veneer graft consists of cutting a 6- to 8-cm strip of cortex of stock and scion. The cut should barely penetrate the wood, thus exposing a broad area of cambium tissue. The two tissues are alined carefully and tightly joined with plastic strips that cover the scion entirely. This covering permits a minimum of dessication of scion tissues. The bud patch is similar to the side-veneer graft, but a smaller piece of wood containing only one instead of several buds is used.

As the scion begins to grow, generally within 4 to 6 weeks, the plastic is gradually removed. The top of the stock should be pruned away a little at a time so that growth of the scion is stimulated. Finally, a cut is made close to the graft union, completely removing the upper portion of the stock. By this time, the scion is large enough to survive on its own. Staking is usually recommended to maintain the fast-growing scion straight and to avoid breakage at the graft union. Usually, the grafts are well established and growing vigorously in 3 months. A light monthly application (1 tsp) of a 6–6–6 or 8–8–8 fertilizer mixture (with one-fourth organic nitrogen) is suggested while the plants are in the 8-l containers, and less if the pot or plastic bag is smaller. When the scions have 40 to 50 cm of new growth, the trees are ready for transplanting to the permanent site.

FIGURE 5.—A 2-year-old canistel tree propagated by cleft grafting.

PLANTING

When feasible, the planting site should be level to gently sloped, or terraced, and free of large obstructions such as boulders and stumps. In permanent plantings of fruit trees, careful attention should be given to good soil aeration and drainage. Heavy clay soils subject to flooding during the rainy season should be avoided. Preferably, the soil should be light and deep, even low in natural fertility if it is well drained. A high water table is a disadvantage in orchards, even if high planting on beds is possible.

The soil should be cleared of trees and other vegetation before planting. In warm tropical areas, deep plowing and disking should be

avoided, because such deep tillage exposes the organic matter to oxidation, with subsequent loss of nutrients. Some removal of stones and roots and some leveling is necessary. Planting patterns should be rectangular or square. Triangular patterns allow for more trees but complicate maintenance and irrigation. On hillsides, contour planting or moderate terracing should be done if economical. Spacing depends on soil type. Trees in deep soils with a high percentage of organic matter need more space, because they grow taller under these conditions. The opposite is true in shallow, low-fertility soils. Recommended spacing for the canistel is 7 by 7 m to 9 by 9 m, and for the lucmo and the abiu the distance is always slightly wider.

If irrigation is available, planting can be done at any time of the year; otherwise, it is better to wait until the start of the rainy season. Planting at this time insures sufficient soil moisture and the best conditions for growth. The grower should have irrigation water at his disposal, because moderate dry spells occur even during the peak rainy season, damaging the young trees. Transplanting should be done carefully to protect the young trees against root damage. Pruning is unnecessary if the roots are undisturbed.

Holes for the trees can be dug by hand or by machine and should be much wider and somewhat deeper than the container. At planting, it is advisable to use compost or a good grade of organic, friable soil around the trees to insure the best root environment. Also, a handful of the 6–6–6 fertilizer mixture used for nursery plants (25 to 30 percent organic) should be mixed thoroughly with the soil at the bottom of the hole.

The most delicate part of transplanting is removing the plastic bag or other container from the tree. During this operation it is easy to dislodge the soil and to damage the roots. The plastic bag should be cut near the base and the sides and carefully removed as the root ball is gently placed into the hole and the hole filled. Plastic bags disintegrate slowly in the soil and should not be left in the holes. The tree is placed in the hole so that when transplanting is complete, the root crown (or portion at ground level) remains at the same level as in the container. As the soil mixture is placed around the root ball, it should be tamped firmly to eliminate air pockets and then watered (10 to 20 l).

After the tree is set, the remaining soil is used to construct a water-retaining basin about 1 m in diameter and up to 10 cm in height. Again, 10 to 20 l of water are applied. Irrigation water is supplied once or twice a week, as needed. Trees should never be allowed to wilt. Drip (trickle) irrigation is particularly beneficial to start young trees.

Fertilization

Because the nutrient requirements of the canistel and its relatives are not well known, it is difficult to specify exact fertilizer needs. Furthermore, requirements vary according to soil type. Wherever these species are grown on a large scale, a soil specialist and a horticulturist should advise the grower. A soil test needs expert interpretation to be of value.

Generally, a newly planted tree needs regular applications of a 6–6–6 or 8–8–8 fertilizer. For the first year, about 50 g applied around the tree every 2 months will give good results under any soil condition. Amounts should be increased gradually, and the frequency of application should be decreased to every 3 to 4 months. After the fourth or fifth year, as the tree begins bearing abundant fruit, the need for phosphorus decreases, but the requirements for nitrogen and potassium remain the same. With volcanic soils that are high in natural potassium, only nitrogen should be applied, twice a year. Regardless of the soil, nitrogen is eventually depleted in orchards, and a fertilizer will be needed to maintain an adequate level of this element in the soil.

Fertilizer should be applied during times of rapid vegetative growth and fruit development. A good time is just before or during the rainy season, or just before the annual flowering. When fertilizer is applied, irrigation is useful if soil moisture is not adequate.

Fertilizer should be spread uniformly around the tree. The mixture need not be incorporated into the soil if rainfall is expected or if sprinkler irrigation is available. Weeds should not be permitted to grow freely under and around fruit trees. Mulching with partially decomposed foliage or soft plant material is the best way to suppress weed growth. If this is done, an additional amount of nitrogen should be applied.

Other Cultural Practices

During the early years of an orchard, a cover

Table 3.—Pests and diseases of the lucmo

Scientific name	Common name	Comments
Aleurothrixus floccosus Mask.	Woolly whitefly	Can be controlled biologically.
Anastrepha serpentina	Fruit fly	Can be attracted to poisoned baits.
Antomolus sp.	Hairy caterpillar	Usually controlled by parasites.
	Burrowing worm	Destroys seed.
Lycaenidae sp.	Green budworm	Usually limited.
Oidium sp.	Powdery mildew	
Saissetia coffeae Walk.	Hemispherical scale	Can be controlled biologically.

crop or a cash crop is desirable. Cover crops reduce weed growth and prevent erosion, improve soil condition, and may add some nitrogen to the soil. Cash crops such as papaya, pineapple, and so forth are advisable, depending on market conditions, if they can be managed so that they do not interfere with the growth of the young trees. Leguminous cover crops include *Calpogonium mucunoides* Desv. (alopo); *Centrosema pubescens* Benth. (butterfly pea); *Pueraria phaseoloides* (Roxb.) Benth. (tropical kudzu); and many others. These vigorous species must be kept in check so that they do not overrun the young trees.

Light pruning is necessary only at the early stages of tree growth and should be limited to providing the tree a good framework, with several well-spaced branches instead of a central leader. Such pruning will give the tree a well-balanced, symmetrical shape with an open canopy. Tall, upright trees are undesirable because they are difficult to harvest and expensive to spray. Suckers from the rootstock should be eliminated, as well as malformed, dead, or diseased branches. Pruning as practiced with temperate fruits should not be done with the canistel and its relatives. Most tropical fruit trees have natural shapes that need not be controlled by pruning. Pruning lowers yields by eliminating potential flowers produced in the young branches at the periphery of the tree.

DISEASES, INSECTS, AND OTHER PESTS

Because the canistel and its relatives are normally grown as isolated trees or in small orchards, serious insect and disease problems are unusual. Some pests of the lucmo (*3*) are summarized in table 3. It can be expected that large-scale commercial plantings of the canistel and its relatives will lead to increased incidence of insects and disease. Pathologists and entomologists should be contacted so that insects and diseases can be monitored and protective treatments made early.

HARVEST

The care taken in the harvest can determine the success of the entire operation. Fruits should be handled gently from the moment they are picked to the time they reach the consumer. Trees have to be watched regularly, because fruits of the canistel and its relatives should be completely mature before they are picked. Each species has characteristic tactile and color clues for maturity, which must be learned by experience.

Fruits of the canistel do not all mature at the same time. They are yellow to orange even when immature, and thus only subtle color and skin-texture differences occur as they mature. Fruits have to be picked to ripen completely. As they soften, the skin texture changes from glossy to dull, and the color intensifies slightly. The immature lucmo fruit is green but begins to change to a brownish orange, almost salmon, as it matures. Some varieties remain green even when mature. For these the grower learns several clues, such as size, amount of russeting, and changes in the intensity of the green. Mature fruit is usually a light green. The fruits of the canistel and its relatives seldom soften completely on the tree. The fruit will drop before ripening. The abiu, which changes from green to yellow, may soften

slightly on the tree. However, it is better to pick the fruit and let it ripen fully on a shelf before eating; otherwise, latex will flow out and stick to the lips.

Fruit should be harvested by hand. If a pole is used, an attachment, such as a cloth bag for catching the fruit, should be installed at one end. Great care must be taken with the picked fruit: it should not be stored in deep containers in which the bottom fruits will be crushed and bruised.

Yields for the canistel and its relatives have not been recorded in detail. Some varieties are capable of producing abundantly, up to 500 fruits or more per tree, an amount considered high enough for normal commercial purposes. Fruits ripen from 3 to 12 days after harvest. Ripening can be delayed by cool temperatures of 15° to 18° C. Lower temperatures will injure the fruit, and they will not ripen properly. The fruits are sorted, cleaned of latex, and carefully packed for shipment. When they reach the market, they should be allowed to ripen on ventilated shelves at room temperature. Ethylene gas will hasten ripening and has been used experimentally to encourage uniform softening.

POSTHARVEST CONSIDERATIONS

Uses

The abiu is always used as a fresh fruit. Because of its agreeable flavor and gelatinous consistency, it goes well in fruit salads, particularly those containing slices of orange to provide acidity, which the abiu lacks.

The canistel and the lucmo are similar, and their uses should be about the same. The lucmo is suitable for a variety of uses, but the canistel is still underutilized. Both can be eaten fresh, either without peeling the skin, or after peeling and slicing. The fruit is rich and satisfying in this form. Supplementary flavoring such as salt or lime juice may be added to taste. Pulp of the fresh fruit can also be used in typical Latin American milkshakes (made without ice cream). This fruit added to milk gives a delightful color and a delicious flavor. The fresh pulp is also cooked in puddings, pies, cakes, and it is used to flavor ice creams and various drinks.

In Peru, the lucmo is ground into a meal that extends the availability of the fruit. Probably, this flour can also be prepared for the canistel. Lucmo meal is prepared in small factories but should be suitable for home processing. In the preparation of the meal, ripe fruit is washed, peeled, and sliced or diced. Pieces of fruit are exposed to hot air (40° C) and turned periodically until dry and hard (a moisture content of about 10 percent). Drying is difficult to accomplish by exposure to the sun alone, but a simple solar drier should be effective at the home level. The moisture content must be low enough so that the product can be stored in a suitable airtight container. The dried fruit can be milled to a fine flour before or after storage.

Lucmo meal is sticky and must be mixed with other ingredients. For the preparation of many drinks and desserts, the meal can be mixed with a small amount of wheat flour, cornmeal, or starch. Lucmo meal adds a strong odor and color to all dishes and therefore is most satisfactory for desserts, including ice creams, sherbets, puddings, punches, milkshakes, and other Peruvian dishes.

The canistel and the lucmo have also been processed into conserves. Because the acidity of the fruit is low, such processing must be done carefully at a high temperature and pressure.

Storage and Shipment

Once ripened, the fruits of the canistel, the lucmo, and the abiu do not store well. Although the fruits can be picked before ripening completely, harvesting should not be done more than 2 weeks early. Once the fruit has ripened, it can be refrigerated for a few days without harm or flavor changes; however, excessive storage in the refrigerator reduces quality. The ripe fruit or the pulp can be preserved and stored by freezing, but this alternative is impractical in most of the Tropics.

Fruits picked when they have matured on the tree but before ripening completely can be shipped long distances by truck, when carefully packed and handled. The postharvest handling and treatment of these fruit species must be studied when commercial orchards are developed.

Nutritive Value

Fruits in general are good sources of vitamins and minerals, fair to good sources of carbohy-

Table 4.—Composition and nutritive value of the canistel and the lucmo

Component		Canistel[1]	Lucmo[2]	RDA[3]
Water	percent	57.2	72.3	...
Protein	g/100 g	2.5	1.5	45
Fat	g/100 g	0.6	0.5	...
Carbohydrate	g/100 g	39.1	25.0	...
Fiber	percent	7.5	1.3	...
Ash	do	0.6	0.7	...
Minerals:				
Calcium	mg/100 g	40	16	800
Iron	mg/100 g	1.1	4.6	10
Phosphorus	mg/100 g	30	26	800
Vitamins:				
Ascorbic acid	mg/100 g	43	5.40	45
Carotene	IU/100 g	2,000	1,500	5,000
Niacin	mg/100 g	2.5	1.96	18
Riboflavin	mg/100 g	0.03	0.14	1.6
Thiamine	mg/100 g	0.02	0.01	1.4

[1] See reference *9*.
[2] See reference *3*.
[3] See reference *10*.

drates, poor to good sources of fats (as oils), and poor sources of protein. The canistel and its relatives are nutritious fruits that could play a significant role in the diet. However, most people eat fruits because they taste good and add variety to the diet.

The canistel and the lucmo are good sources of carotene (provitamin A) (table 4), but the abiu is lacking in this important vitamin. The vitamin-C (ascorbic acid) content is fairly high in the canistel but moderate in the lucmo. The iron content is good in the lucmo and moderate in the canistel. Niacin (vitamin B_3) content is excellent in the canistel and the lucmo, compared with the niacin content in other fruits. Other vitamins and minerals are also present in useful amounts. The fat content of these fruits is negligible, but the carbohydrate content is good. These species are higher in protein than most fruits, but the amount is not high enough to be nutritionally significant.

REFERENCES

(1) Brown, W. H. 1958. Useful plants of the Philippines. Philipp. Dep. Agric. Commer. Tech. Bull. 10, vol. 3, 505 pp.

(2) Burkill, I. H. 1966. A dictionary of the economic products of the Malay Peninsula. 2444 pp. Ministry of Agriculture and Co-operatives, Kuala Lumpur, Malaysia.

(3) Calzada, J.; Bautista, V.; Bermudez, J.; and Moran, M. 1972. Cultivo del lúcumo. Univ. Nac. Agrar. (La Molina, Perú) Bol. Tec. 2, 44 pp.

(4) Cavalcante, P. R. 1976. Frutas comestíveis da Amazônia. 166 pp. Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas.

(5) Cronquist, Arthur. 1946. Studies in the Sapotaceae. II. Survey of the North American genera. Lloydia 9(4): 241–292.

(6) Duarte, B. O., and Francoise, T. R. 1976. Recent advances in the propagation of some tropical and subtropical species in Peru. 1st Inter. Symp. Trop. Subtrop. Fruits, Lima, Peru. Acta Hortic. 57: 15–20.

(7) Ebel, C. 1935. Los lúcumos en Chile. Rev. Chile Hist. Nat. 34: 183–203.

(8) Fouqué, A. 1972. Espèces fruitières d'Amérique tropicale—famille des Sapotacees. Fruits 27 (9): 633–643.

(9) Intengan, C. L.; Abdon, I. C.; Alejo, L. G.; and Palad, J. G. 1968. Food composition table recommended for use in the Philippines. 134 pp. Food and Nutrition Research Center, Manila.

(10) National Research Council. 1974. Recommended Dietary Allowances. 8th ed. Washington.

(11) Pittier, Henry. 1914. New or noteworthy plants from Columbia and Central America—4. U.S. National Herbarium, Smithsonian Institution, vol. 18, pt. 2, 65–86.

(12) Saavedra, E. 1975. Efecto de la temperature y reguladores de crecimiento sobre la germinación y crecimiento de la plántula del lúcumo (*Lucuma bifera* Mol.). Invest. Agric. (Chile) 1(3): 147–152.

(13) ———. 1975. Injertación del lúcumo. Invest. Agric. (Chile) 1(3): 191–193.

(14) Standley, Paul C. 1930. Flora of Yucatán. 492 pp. Field Museum of Natural History, Botanical Series, vol. III, No. 3 (Publ. 279), Chicago.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—771-106/01

U. S. DEPARTMENT OF AGRICULTURE
SCIENCE AND EDUCATION ADMINISTRATION
P. O. BOX 53326
NEW ORLEANS, LOUISIANA 70153

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE
U. S. DEI
AGRICULTURE
AGR 101